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JC07 Rec'd PCT/PTO 22 FEB 2002

FORM PTO-1390 (REV. 9-2001) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

# TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: Eryurtlu - 2

U.S. APPLICATION NO (If known, see 37 CFR 1.5): 10/069687

| INTERNATIONAL APPLICATION NO. | INTERNATIONAL FILING DATE | PRIORITY DATE CLAIMED |
|---|---|---|
| PCT/GB00/01842 | 05/15/2000 | 08/31/1999 |

TITLE OF INVENTION
Apparatus For Compressing And Expanding Video Data

APPLICANT(S) FOR DO/EO/US
Eryurtlu, F.M.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. [x] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [x] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [x] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [x] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [x] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [x] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [x] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [x] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [x] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11 to 20 below concern document(s) or information included:**

11. [x] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [x] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. [x] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4)
20. [ ] Other items or information:

"Express Mail" mailing label number EE821591816US
Date of Deposit 2/22/02
I hereby certify that this paper is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks Washington, D.C. 20231
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| U.S. APPLICATION NO. (if known, see 37 CFR 1.5) | INTERNATIONAL APPLICATION NO | ATTORNEY'S DOCKET NUMBER |
|---|---|---|
| 10/069687 | PCT/GB00/01842 | Eryurtlu - 2 |

| | CALCULATIONS | PTO USE ONLY |
|---|---|---|
| 21. [x] The following fees are submitted:<br>**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):**<br>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .... **$1040.00**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO . **$890.00**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO . .... **$740.00**<br>International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) .......... **$710.00**<br>International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ...... ...... **$100.00** | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | $ 890.00 | |
| Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). | $ | |

| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | |
|---|---|---|---|---|---|
| | | | | $ | |
| Total claims | 14 - 20 = | | x **$18.00** | $ | |
| Independent claims | 2 - 3 = | | x **$84.00** | $ | |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | + **$280.00** | $ 890.00 | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $ | |
| [ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. + | | | | $ | |
| **SUBTOTAL =** | | | | $ 890.00 | |
| Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). | | | | $ | |
| **TOTAL NATIONAL FEE =** | | | | $ | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property + | | | | $ 40.00 | |
| **TOTAL FEES ENCLOSED =** | | | | $ 930.00 | |
| | | | | **Amount to be refunded:** | $ |
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b. [x] Please charge my Deposit Account No. 12-2325 in the amount of $ 930.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 12-2325. A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Gregory J. Murgia
NAME

41209
REGISTRATION NUMBER

**IN THE UNITED STATES**
**PATENT AND TRADEMARK OFFICE**

**Patent Application**

| | | |
|---|---|---|
| Inventor(s) | Faruk Mehmet Eryurtlu | |
| Case | 2 | |
| Serial No. | | Group Art |
| File Date | | |
| Examiner | | |
| Title | APPARATUS FOR COMPRESSING AND EXPANDING VIDEO DATA | |

ASSISTANT COMMISSIONER FOR PATENTS AND TRADEMARK
WASHINGTON, DC 20231

Dear Sir:

## PRELIMINARY AMENDMENT

The version of the claims showing the changes made to the claims of the application are attached for your review.

**In The Claims:**

Please replace claims 1, 2, 5, 8-10 and 13-14 as follows:

1. (amended) Apparatus for coding video data, comprising means for receiving pixel values organised in frames each comprising a matrix of video blocks, each video block comprising a video matrix of N pixel values, and processor means arranged:

a) to set each element in a prediction matrix to an initial prediction value;

b) in the prediction matrix, to apply a smoothing transform to the values along the rows and then along the columns, or vice versa, to obtain interpolated values;

c) to reset the prediction value to the interpolated value;

d) to calculate the difference between the reset prediction values and corresponding received pixel values to produce a residual prediction matrix containing the prediction residuals; and

e) to perform a discrete cosine transform on the prediction residuals to obtain elements of a compressed video data matrix.

2. (amended) Apparatus as claimed in claim 1, wherein the processor means is arranged iteratively to calculate the reset prediction value used to calculate the prediction residual by repeating b) and c).

5. (amended) Apparatus as claimed in claim 1, wherein a) is performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting *n* of the coefficients, setting the N-*n* remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

8. (amended) Apparatus as claimed in claim 1, including means for processing pixels in a current and a previous frame to produce pixel values which are the prediction residual between the actual pixel and a motion compensated pixel.

9. (amended) Apparatus for expanding compressed video data, comprising processor means arranged:

a) to perform an inverse discrete cosine transform on received compressed video data to obtain a prediction residual matrix;

b) to set each element in a prediction block matrix to the initial prediction value;

c) in the prediction matrix, to apply a smoothing transform to the values along the rows and then along the columns, or vice versa, to obtain interpolated values;

d) to reset the prediction value to the interpolated value; and

e) to calculate the sum of the reset prediction values and the prediction residual in corresponding positions in the received coded block matrix to produce an expanded video data matrix.

10. (amended) Apparatus as claimed in claim 9, wherein the processor means is arranged iteratively to calculate the reset prediction value used to calculate the prediction residual by repeating b) and c).

13. (amended) Apparatus as claimed in claim 9, wherein a) is performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting *n* of the coefficients, setting the N-*n* remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

14. (amended) Apparatus as claimed in claim 13 for expanding compressed video data, wherein the processor is arranged to select N – *n* elements from the compressed video data matrix and to set *n* elements to zero before performing the inverse discrete cosine transform to obtain the prediction residual matrix.

## REMARKS

By way of the Preliminary Amendment, Applicant has amended the claims in the above-identified application in accordance with typical U.S. patent practice. In the event of any fees inadvertently omitted or any improper payment of fees, the Commissioner is hereby authorized to charge or credit Lucent Technologies Deposit Account No.12-2325 to correct the error now or during the pendency of this application, except for the issue fee.

If the Examiner has any questions or feels that a telephone conversation would be helpful, please contact Julio Garceran at (973) 386-2286.

Respectfully submitted,
Faruk Mehmet Eryurtlu

By: 
Julio A. Garceran, Attorney
Reg. No. 37,138

Lucent Technologies Inc.

Date: 1/3/02

## VERSION OF CLAIMS SHOWING CHANGES

1. (amended) Apparatus for coding video data, comprising means for receiving pixel values organised in frames each comprising a matrix of video blocks, each video block comprising a video matrix of N pixel values, and processor means arranged [to perform the following steps]:

a) to set each element in a prediction matrix to an initial prediction value;

b) in the prediction matrix, to apply a smoothing transform to the values along the rows and then along the columns, or vice versa, to obtain interpolated values;

c) to reset the prediction value to the interpolated value;

d) to calculate the difference between the reset prediction values and corresponding received pixel values to produce a residual prediction matrix containing the prediction residuals; and

e) to perform a discrete cosine transform on the prediction residuals to obtain elements of a compressed video data matrix.

2. (amended) Apparatus as claimed in claim 1, wherein the processor means is arranged iteratively to calculate the reset prediction value used to calculate the prediction residual by repeating [steps] b) and c).

5. (amended) Apparatus as claimed in [any preceding] claim 1, wherein [step] a) is performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting $n$ of the coefficients, setting the N-$n$ remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

8. (amended) Apparatus as claimed in [any preceding] claim 1, including means for processing pixels in a current and a previous frame to produce pixel values

which are the prediction residual between the actual pixel and a motion compensated pixel.

9. (amended) Apparatus for expanding compressed video data [compressed by apparatus as claimed in any preceding claim], comprising [means for receiving the compressed video matrix, and] processor means arranged [to perform the following steps]:

a) to perform an inverse discrete cosine transform on received compressed video data to obtain a prediction residual matrix;

b) to set each element in a prediction block matrix to the initial prediction value;

c) in the prediction matrix, to apply a smoothing transform to the values along the rows and then along the columns, or vice versa, to obtain interpolated values;

d) to reset the prediction value to the interpolated value; and

e) to calculate the sum of the reset prediction values and the prediction residual in corresponding positions in the received coded block matrix to produce an expanded video data matrix.

10. (amended) Apparatus as claimed in claim [8] 9, wherein the processor means is arranged iteratively to calculate the reset prediction value used to calculate the prediction residual by repeating [steps] b) and c).

13. (amended) Apparatus as claimed in [any of] claim[s] 9 [to 12], wherein [step] a) is performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting $n$ of the coefficients, setting the N-$n$ remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

14. (amended) Apparatus as claimed in claim 13 for expanding compressed video data [compressed by apparatus as claimed in claim 7], wherein the processor is arranged to select N – $n$ elements from the compressed video data matrix and to set $n$ elements to zero before performing the inverse discrete cosine transform to obtain the prediction residual matrix.

# APPARATUS FOR COMPRESSING AND EXPANDING VIDEO DATA

This invention relates to apparatus for compressing and expanding video data.

Existing video compression standards are all based on block discrete cosine transform (DCT) transform. The picture is divided into square blocks consisting of 8x8 pixels. The blocks may contain the actual pixels or the prediction residual, which is the difference between the actual and motion compensated bock pixels. Each block is transformed into DCT domain, which results in 8x8 coefficients.

The DCT process is used to remove the spatial redundancy between the pixels in the same block. However, it does not consider the redundancy between the pixels from different blocks. The first versions of the standards did not use any technique to exploit the correlation between different blocks. Recently, MPEG-4 and H.263+ have added tools/options to exploit this redundancy to certain extent. At present, MPEG-4 predicts the DC coefficient (first coefficient, which is actually the block average) of the current block by using the DC coefficients of the neighbouring blocks. H.263+ does this, and in addition, it also predicts the first row or column of the DCT coefficients in some cases if there is any benefit.

In brief, existing compression algorithms exploit the fact that the DCT coefficients in the neighbouring blocks are sometimes similar to those in the current block. This means that if the blocks contain completely different coefficients, the prediction will not work.

Yuuji Izawa Et Al: 'Improvement of Picture Quality and Coding Efficiency Using Discrete Cosine Transform' Electronics & Communications in Japan, Part 1- Communications, US, Scripta Technica, New York, vol. 73, no. 6, 1 June 1990 (1990-06-01), pages 12-21, XP000170744 ISSN: 8756-6621 discloses apparatus for coding video data, comprising means for receiving pixel values organised in frames each comprising a matrix of video blocks, each video block comprising a video matrix of N pixel values, and processor means arranged to perform the following steps:

a) to set each element in a prediction matrix to an initial prediction value;

b) in the prediction matrix, to apply a smoothing transform to the values along rows and then along columns, or vice versa, to obtain interpolated values;

c) to set the prediction values to the interpolated values;

d) to calculate the differences between the prediction values and corresponding received pixel values to produce a residual prediction matrix containing prediction residuals.

The present invention is characterised over the disclosure of the Yuuji Izawa et al. paper mentioned above in that the processor means is also arranged

e) to perform a discrete cosine transform on the prediction residuals to obtain elements of a compressed video data matrix, wherein the processor means is arranged iteratively to calculate the prediction values used to calculate the prediction residuals by repeating steps b) and c.

The number of iterations may be predetermined or, in an alternative, the iterations may be repeated until the change in the prediction value between one iteration and the next, is less than a predetermined threshold.

Step a) is most preferably performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting *n* of the coefficients, setting the N-*n* remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

In that case, the processor is preferably arranged to set *n* of the elements in the compressed video data matrix equal to the *n* coefficients selected from the transform video matrix, and to select the remaining N-*n* coefficients from the prediction residuals.

The processor is further preferably arranged to adjust the prediction residuals before selecting the remaining N – *n* elements, by:

f) performing a discrete cosine transform on the reset prediction value matrix to obtain a prediction transform matrix,

g) selecting *n* coefficients from the transform prediction matrix,

g) selecting $n$ coefficients from the transform prediction matrix,

h) subtracting the selected $n$ transform prediction matrix coefficients from the selected $n$ transform video coefficients to obtain $n$ residual coefficients;

i) setting $n$ elements of an adjustment transform matrix to the values of the $n$ residual coefficients and setting $N - n$ remaining elements to zero;

j) performing an inverse discrete cosine transform on the adjustment transform matrix to obtain an adjustment value matrix; and

k) subtracting the adjustment value matrix from the reset prediction value matrix.

The apparatus may include means for processing pixels in a current and a previous frame to produce pixel values which are the prediction residual between the actual pixel and a motion compensated pixel.

The invention extends to apparatus for expanding video data compressed by apparatus as claimed in any preceding claim, comprising means for receiving the compressed video matrix, and processor means arranged to perform the following steps:

a) to perform an inverse discrete cosine transform on received compressed video data to obtain a prediction residual matrix;

b) to set each element in a prediction matrix to the initial prediction value;

c) in the prediction matrix, to apply a smoothing transform to the values along the rows and then along the columns, or vice versa, to obtain interpolated values;

d) to reset the prediction value to the interpolated value; and

e) to calculate the sum of the reset prediction values and the prediction residual in corresponding positions in the received coded block matrix to produce an expanded video data matrix.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figures 1A and 1B, when assembled as shown in Figure 1, show a block diagram of a transmitter including apparatus for compressing video data embodying the invention; and

Figures 2A and 2B, when assembled as shown in Figure 2, show a block diagram of a receiver including apparatus for expanding the video data compressed by the apparatus of Figure 1.

A frame of quantised and digitised pixel values is divided into video matrices comprising blocks of N pixels where as an example N = 8 x 8. With a switches 1a, 1b set to "intra" as illustrated, a video matrix 2 is discrete cosine transformed in step 4 to produce a video transform matrix 6 comprising a block of N discrete cosine transform (DCT) coefficients where in the example N = 8 x 8. Of these a square of *n* coefficients are selected in step 8, essentially the DC coefficient and optionally other coefficients.

In step 10, the remaining N – *n* (i.e. 8 x 8 –*n*) coefficients are set to zero to obtain an initial prediction transform matrix 12. The coefficients are inverse discrete cosine transformed in step 14 to obtain an initial prediction matrix 16.

In step 18 interpolation is performed between the initial prediction values of matrix 16 and the values in the neighbouring preceding blocks to reset the prediction matrix. Values in a row 20, spatially nearest to the video matrix 2, are used in the interpolation process. Linear interpolation is performed between the value in a row/column position in the initial prediction matrix and the value in a corresponding column in row 20 weighted according to the distance in rows from the row 20.

Similarly values in a column 22, spatially nearest the video matrix 2, are used in the interpolation process. Linear interpolation is also performed between the value in a row/column position in the initial prediction matrix and the value in a corresponding row in column 22, weighted by the distance in columns from the column 22.

$$V_{interpolated} = \{2V_{r,c} + V_{20,c}/r + V_{r.22}/c\}\ ¼$$

Where,

$V_{interpolated}$ is the interpolated prediction value, $V_{r,c}$ is the value at row *r* column *c* of the initial prediction matrix 16, $V_{20,c}$ is the value in column *c* of row 20, r is the distance in rows of the position r,c from row 20, $V_{r,22}$ is the value at row *r* in column 22, and c is the distance in columns of the position r,c from the column 22.

The interpolation step 18 is performed iteratively until, in one example, the change in values in one step is less than a predetermined threshold. In another example, a predetermined fixed number of iterations is performed.

When the iterations are complete, the reset prediction values are discrete cosine transformed in step 24 to obtain 8 x 8 coefficients of a transform prediction matrix 26. In step 28 *n* coefficients are selected and, in step 30 subtracted from the *n* video transform coefficients previously selected in step 8 to produce *n* residual coefficients. In step 32 the remaining 8 x 8 –*n* coefficients are set to zero to obtain 8 x 8 adjustment coefficients 34. These are inverse discrete cosine transformed to produce 8 x 8 adjustment values.

The values of the reset prediction matrix are adjusted by subtracting from them the adjustment values. The values in the video matrix are subtracted from the adjusted reset prediction values to obtain a prediction residual matrix 34 of 8 x 8 values. In step 36, the prediction residual values are discrete cosine transformed to produce a transform residual matrix having 8 x 8 coefficients. Of these *n* will be zero because of the adjustment made to the reset prediction matrix.

The remaining 8 x 8 –*n* coefficients are selected in step 38 and assembled with the *n* video transform coefficients previously selected in step 8 to provide a compressed

video matrix of 8 x 8 coefficients. These are channel coded in step 40 and transmitted through a medium 42.

In the apparatus shown in Figures 2A and 2B, the signal received from the medium 42 is channel decoded in step 44 to produce a decoded compressed video data matrix 46 of 8 x 8 coefficients. Of these, *n* are selected in step 48 and the remaining 8 x 8 −*n* are set to zero in step 50 to obtain a decoded initial prediction transform matrix 52 having 8 x 8 coefficients. The coefficients are inverse discrete cosine transformed to produce a +

decoded initial prediction matrix 54 having 8 x 8 initial prediction values.

In step 56, interpolation is performed iteratively on the initial prediction matrix in exactly the same manner as was performed in step 18 on the prediction matrix 16 using the (decoded) neighbouring row 20 and column 22 to obtain a matrix 58 of reset prediction values.

In step 60, the remaining 8 x 8 − *n* coefficients of matrix 46 are selected and *n* coefficients are set to zero in step 62 to obtain a decoded transform residual matrix 64 having 8 x 8 coefficients. These coefficients are inverse discrete cosine transformed in step 66 to obtain a decoded prediction residual matrix having 8 x 8 residual values. In step 68 these are added to the reset prediction values in matrix 58 to produce a decoded video matrix 70 containing 8 x 8 pixel values corresponding to those of matrix 2.

Putting the switches 1a, 1b in their “inter” position, rearranges the apparatus to operate not on the current frame video matrix, but on the residual produced by subtracting the values in a motion compensated block of a previous frame, from the values in the current frame video matrix 2 in step 74. The motion compensated values

are added back in step 76 to produce the initial prediction matrix 16 values, and subtracted in step 78 from the reset prediction values.

In the expander shown in Figure 2, motion compensated values obtained in a decoded motion compensated video matrix 80 from a previously decoded frame, are added back in step 82 to produce the initial prediction matrix.

**Claims**

**1.** Apparatus for coding video data, comprising means for receiving pixel values organised in frames each comprising a matrix of video blocks, each video block comprising a video matrix of N pixel values, and processor means arranged to perform the following steps:

a) to set each element in a prediction matrix to an initial prediction value;

b) in the prediction matrix, to apply a smoothing transform to the values along rows and then along columns, or vice versa, to obtain interpolated values;

c) to set the prediction values to the interpolated values;

d) to calculate the differences between the prediction values and corresponding received pixel values to produce a residual prediction matrix containing prediction residuals; and characterised in that the processor means is also arranged

e) to perform a discrete cosine transform on the prediction residuals to obtain elements of a compressed video data matrix wherein the processor means is arranged iteratively to calculate the prediction values used to calculate the prediction residuals by repeating steps b) and c).

**2.** Apparatus as claimed in claim 1, wherein the number of iterations is predetermined.

**3.** Apparatus as claimed in claim 1, wherein the processor means is arranged to repeat the iterations until the change in the prediction value between one iteration and the next, is less than a predetermined threshold.

**4.** Apparatus as claimed in any preceding claim, wherein step a) is performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting *n* of the coefficients, setting the N-*n* remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

5. Apparatus as claimed in claim 4 wherein the processor is arranged to set *n* of the elements in the compressed video data matrix equal to the *n* coefficients selected from the transform video matrix, and to select the remaining N-*n* coefficients from the prediction residuals.

6. Apparatus as claimed in claim 5 wherein the processor is arranged to adjust the prediction residuals before selecting the remaining N – *n* elements, by:

f) performing a discrete cosine transform on the reset prediction value matrix to obtain a prediction transform matrix,

g) selecting *n* coefficients from the transform prediction matrix,

h) subtracting the selected *n* transform prediction matrix coefficients from the selected *n* transform video coefficients to obtain *n* residual coefficients;

i) setting *n* elements of an adjustment transform matrix to the values of the *n* residual coefficients and setting N –*n* remaining elements to zero;

j) performing an inverse discrete cosine transform on the adjustment transform matrix to obtain an adjustment value matrix; and

k) subtracting the adjustment value matrix from the reset prediction value matrix.

7. Apparatus as claimed in any preceding claim, including means for processing pixels in a current and a previous frame to produce pixel values which are the prediction residual between the actual pixel and a motion compensated pixel.

8. Apparatus for expanding video data compressed by apparatus as claimed in any preceding claim, comprising means for receiving the compressed video matrix, and processor means arranged to perform the following steps:

a) to perform an inverse discrete cosine transform on received compressed video data to obtain a prediction residual matrix;

b) to set each element in a prediction block matrix to the initial prediction value;

c) in the prediction matrix, to apply a smoothing transform to the values along rows and then along columns, or vice versa, to obtain interpolated values;

d) to the prediction values to the interpolated values; and

e) to calculate the sums of the prediction value and the prediction residual in corresponding positions in the received coded block matrix to produce an expanded video data matrix.

**9.** Apparatus as claimed in claim 8, wherein the processor means is arranged iteratively to calculate the prediction values used to calculate the prediction residuals by repeating steps b) and c).

**10.** Apparatus as claimed in claim 9, wherein the number of iterations is predetermined.

**11.** Apparatus as claimed in claim 9, wherein the processor means is arranged to repeat the iterations until the change in the prediction value between one iteration and the next, is less than a predetermined threshold.

**12.** Apparatus as claimed in any of claims 8 to 11, wherein step a) is performed by performing a discrete cosine transform on the video matrix to obtain a transform video matrix of N coefficients, selecting $n$ of the coefficients, setting the N-$n$ remaining coefficients to zero to obtain an initial prediction transform matrix of initial prediction coefficients, and performing an inverse discrete cosine transform on the initial prediction transform matrix to obtain a matrix of N initial prediction values.

**13.** Apparatus as claimed in claim 12 for expanding video data compressed by apparatus as claimed in claim 7, wherein the processor is arranged to select N-$n$ elements from the compressed video data matrix and to set $n$ elements to zero before performing the inverse discrete cosine transform to obtain the prediction residual matrix.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)


(19) World Intellectual Property Organization
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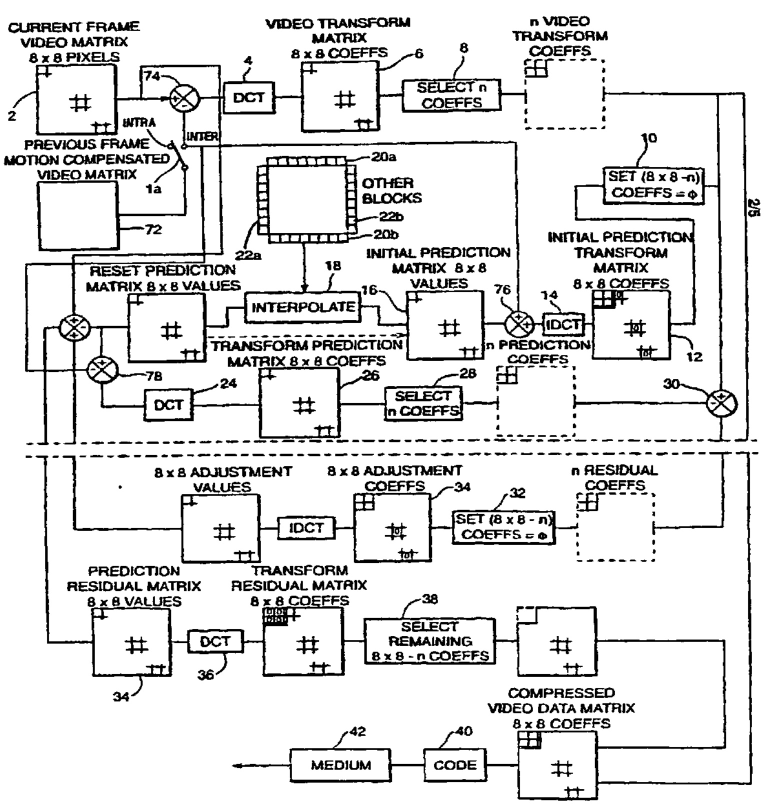
(54) Title: METHOD AND APPARATUS FOR MACROBLOCK DC AND AC COEFFICIENT PREDICTION FOR VIDEO CODING





**(57) Abstract:** Existing video data compression algorithms exploit the fact that the DCT coefficients in the neighbouring blocks are sometimes similar to those in the current block. This means that if the blocks contain completely different coefficients, the prediction will not work. Apparatus for coding video data is disclosed in which element in a prediction matrix is set to an initial prediction value. In the prediction matrix, a smoothing transform is applied to the values along the rows and then along the columns, or vice versa, to obtain interpolated values. The prediction value is reset to the interpolated value and the difference between the reset prediction values and corresponding received pixel values is calculated to produce a residual prediction matrix containing the prediction residuals. A discrete cosine transform is performed on the prediction residuals to obtain elements of a compressed video data matrix. The processor means is preferably arranged iteratively to calculate the reset prediction value used to calculate the prediction residual by repeating steps b) and c).


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FIG. 1

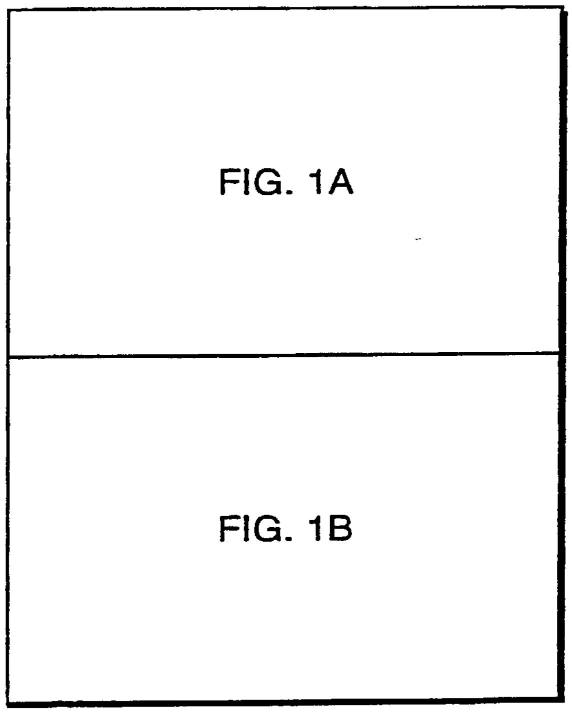
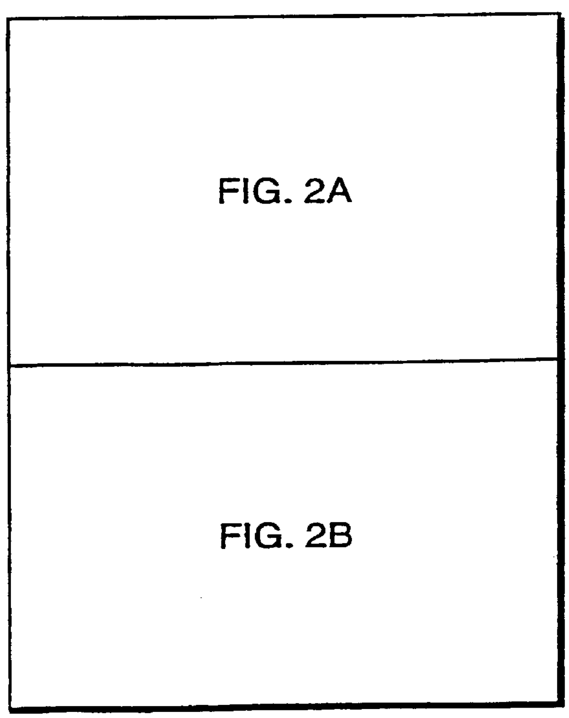



FIG. 2



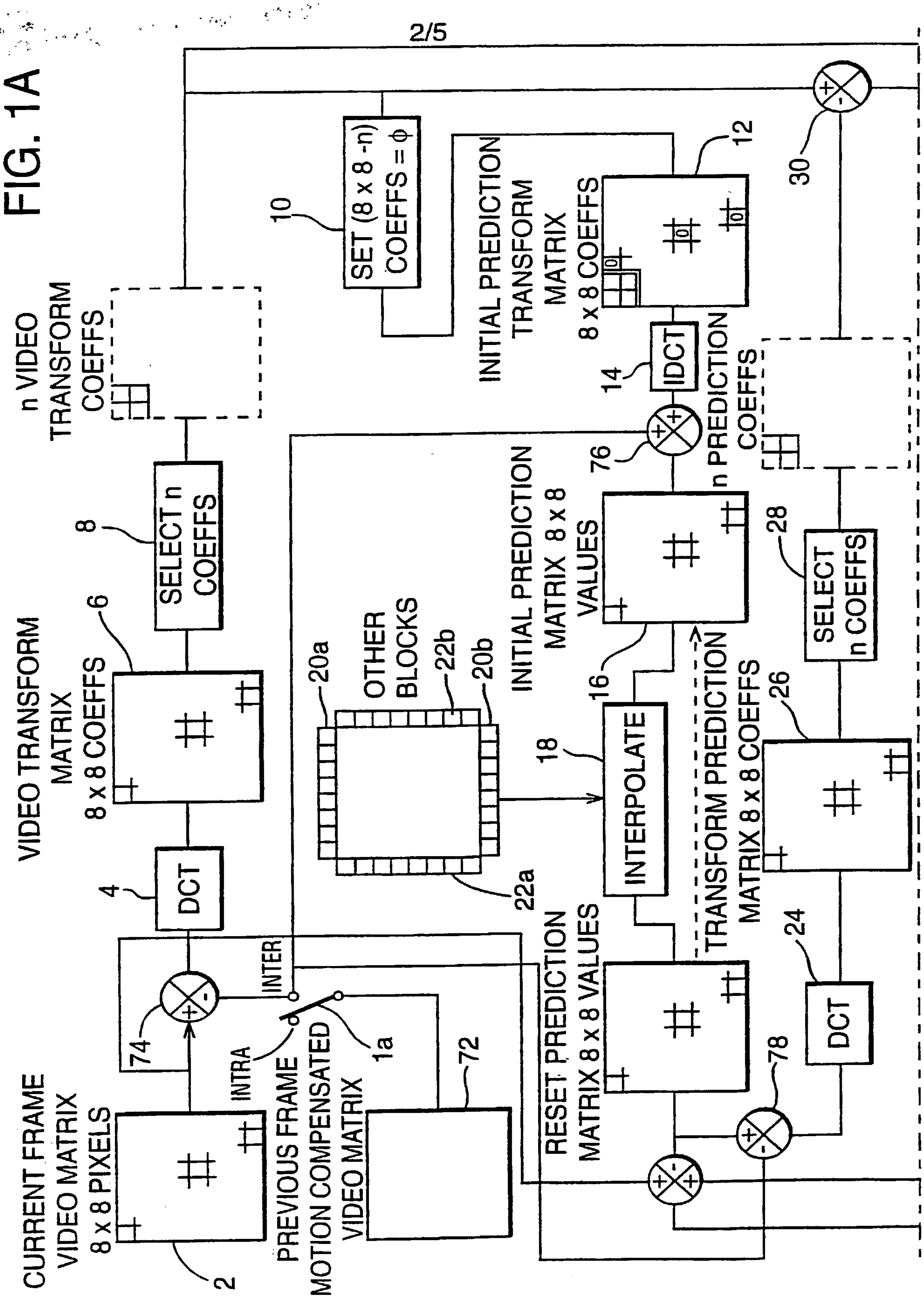

CURRENT FRAME VIDEO MATRIX 8 x 8 PIXELS
2
74
INTRA
INTER
1a
PREVIOUS FRAME MOTION COMPENSATED VIDEO MATRIX
72
4
DCT
VIDEO TRANSFORM MATRIX 8 x 8 COEFFS
6
8
SELECT n COEFFS
n VIDEO TRANSFORM COEFFS
10
SET (8 x 8 -n) COEFFS = ϕ
INITIAL PREDICTION TRANSFORM MATRIX 8 x 8 COEFFS
12
14
IDCT
76
n PREDICTION COEFFS
30
20a
OTHER BLOCKS
22b
20b
22a
18
INTERPOLATE
16
INITIAL PREDICTION MATRIX 8 x 8 VALUES
TRANSFORM PREDICTION MATRIX 8 x 8 COEFFS
26
28
SELECT n COEFFS
24
DCT
RESET PREDICTION MATRIX 8 x 8 VALUES
78

FIG. 1A

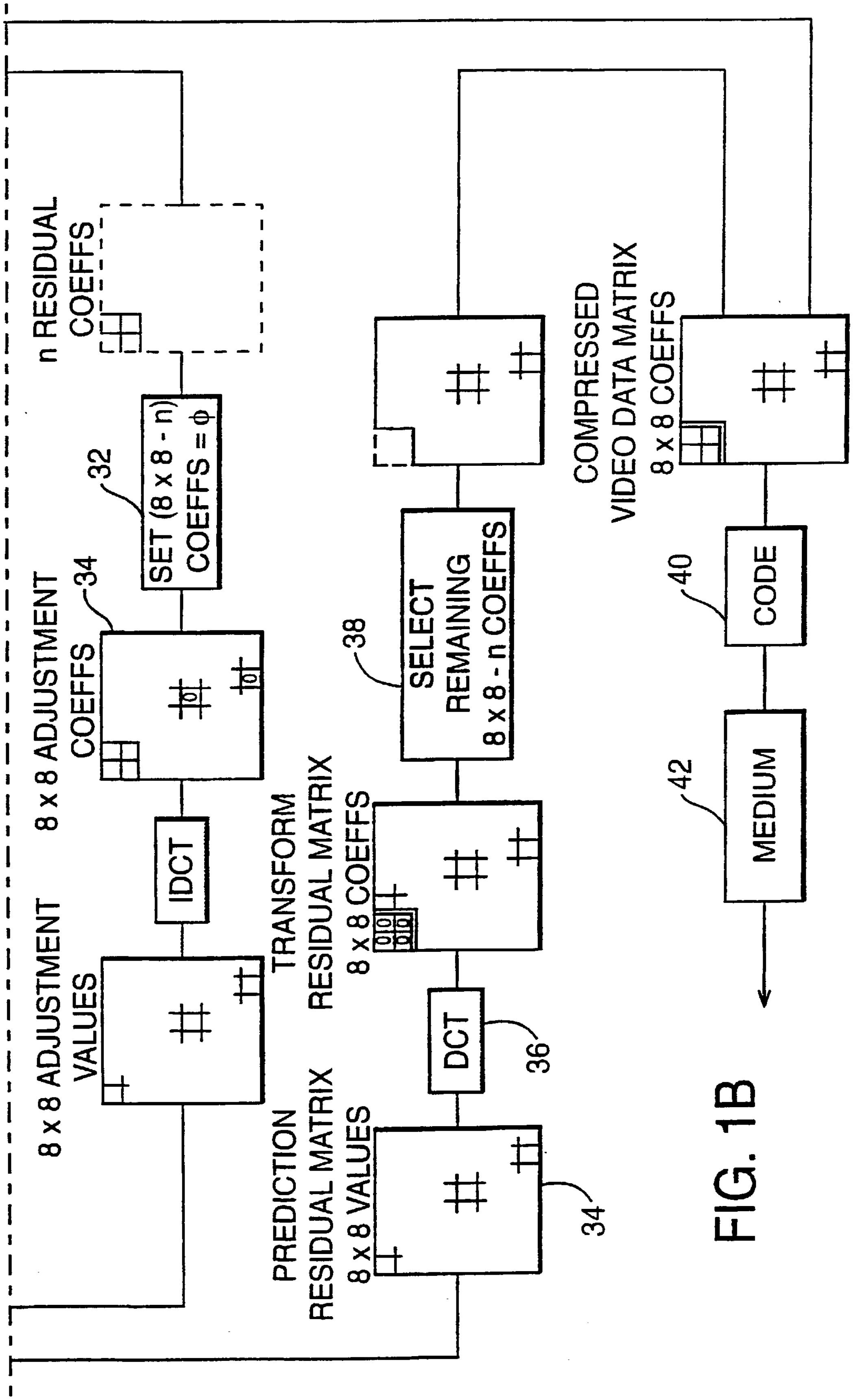
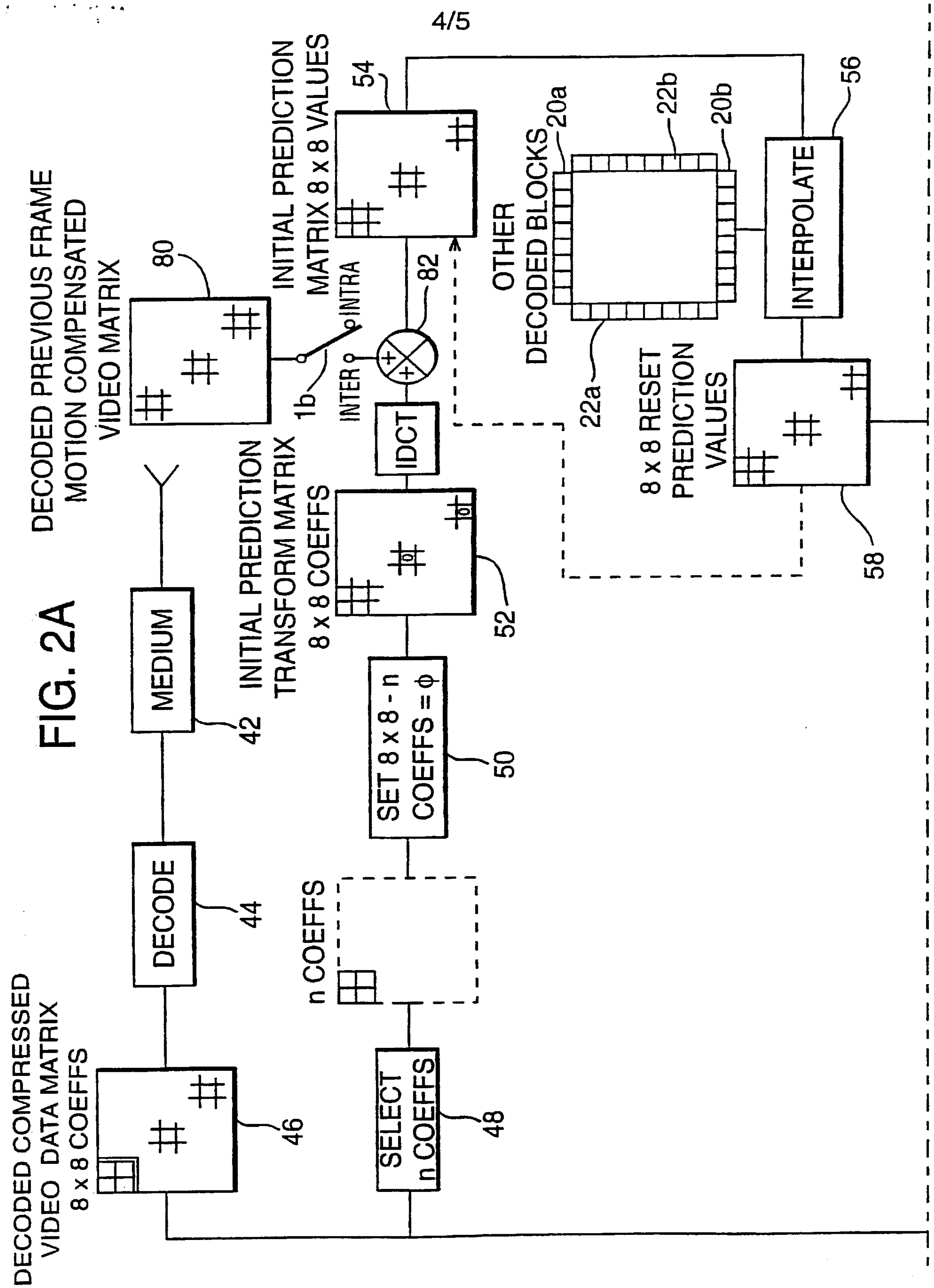

8 x 8 ADJUSTMENT VALUES
IDCT
8 x 8 ADJUSTMENT COEFFS
34
SET (8 x 8 - n) COEFFS = ϕ
32
n RESIDUAL COEFFS
PREDICTION RESIDUAL MATRIX 8 x 8 VALUES
34
DCT
36
TRANSFORM RESIDUAL MATRIX 8 x 8 COEFFS
SELECT REMAINING 8 x 8 - n COEFFS
38
COMPRESSED VIDEO DATA MATRIX 8 x 8 COEFFS
CODE
40
MEDIUM
42

FIG. 1B

FIG. 2A


DECODED COMPRESSED VIDEO DATA MATRIX 8 x 8 COEFFS
46
DECODE
44
MEDIUM
42
SELECT n COEFFS
48
n COEFFS
SET 8 x 8 - n COEFFS = ϕ
50
INITIAL PREDICTION TRANSFORM MATRIX 8 x 8 COEFFS
52
IDCT
INTER
INTRA
1b
82
DECODED PREVIOUS FRAME MOTION COMPENSATED VIDEO MATRIX
80
INITIAL PREDICTION MATRIX 8 x 8 VALUES
54
OTHER DECODED BLOCKS
20a
22b
20b
22a
INTERPOLATE
56
8 x 8 RESET PREDICTION VALUES
58

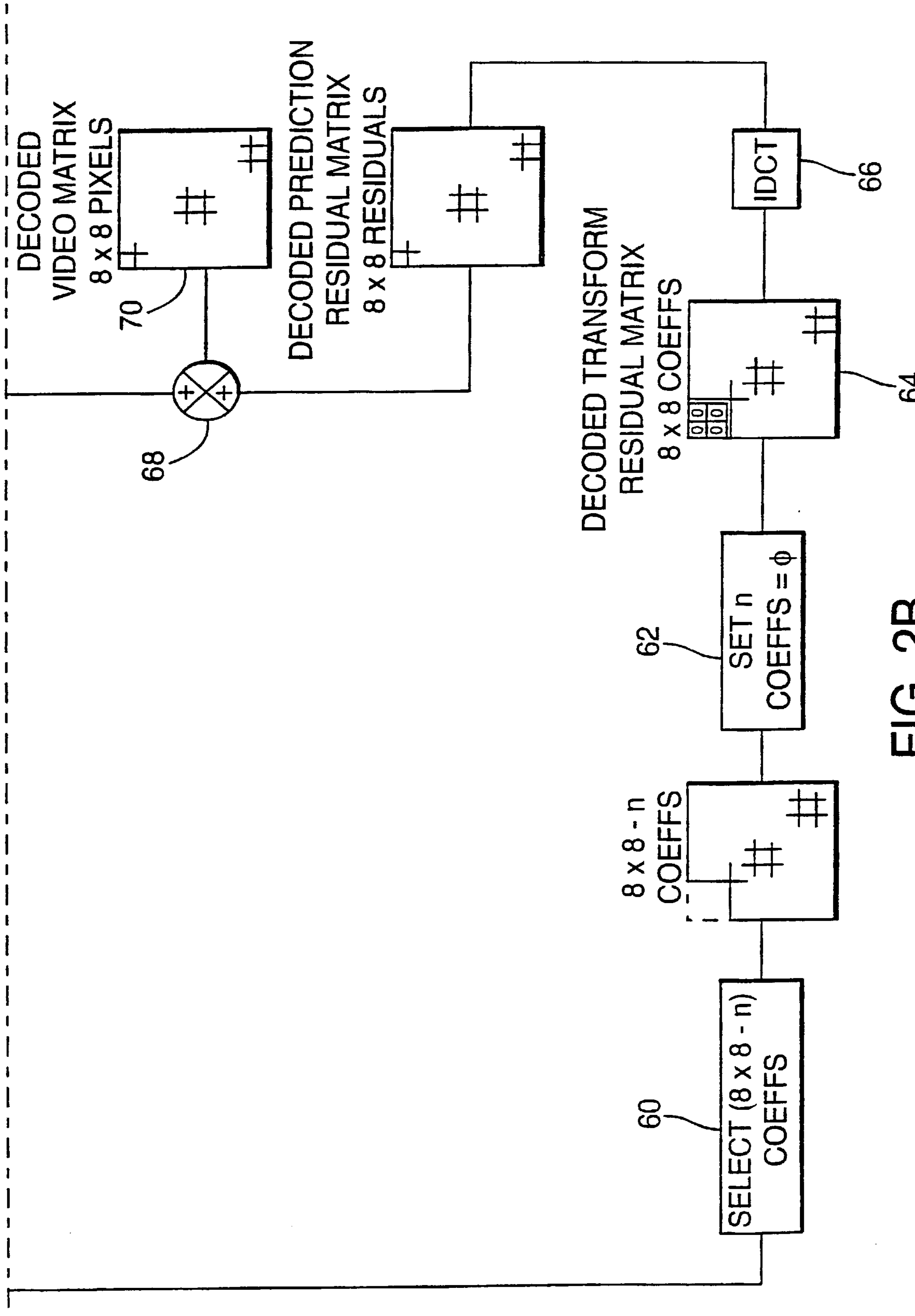

DECODED
VIDEO MATRIX
8 x 8 PIXELS
70
DECODED PREDICTION
RESIDUAL MATRIX
8 x 8 RESIDUALS
68
IDCT
66
DECODED TRANSFORM
RESIDUAL MATRIX
8 x 8 COEFFS
64
62
SET n
COEFFS = ϕ
8 x 8 - n
COEFFS
60
SELECT (8 x 8 - n)
COEFFS

FIG. 2B

F.M. Eryurtlu 2

IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE

Declaration and Power of Attorney

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **Method And Apparatus For Macroblock DC And AC Coefficient Prediction for Video Coding** the specification of which

[√] is attached hereto

OR

[ ] was filed on ___________ and granted Application Serial Number _____________.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment, if any, specifically referred to in this oath or declaration.

I acknowledge the duty to disclose all information known to me which is material to patentability as defined in Title 37, Code of Federal Regulations, 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

**European Application No. 99306931.9 filed August 31, 1999**

I hereby claim the benefit under Title 35, United States Code, 120 of any foreign application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

| **International Patent Application No.** | **Filing Date** | **Status** |
| --- | --- | --- |
| **PCT/GB00/01842** | **15th May 2000** | **Pending** |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States

Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorney(s) with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith:

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**I hereby authorize these attorneys to insert in the above blanks the filing date and application serial no. when known.**

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